ADOT ECS File: JPA 98-38
Project No. SPR-467
TRACS No.: R0468 10P
Research: Accelerated Pavement Testing

INTERAGENCY AGREEMENT
BETWEEN
THE DEPARTMENT OF TRANSPORTATION
AND
THE ARIZONA STATE UNIVERSITY

THIS AGREEMENT is entered into 17 APR 11, 1998, between agencies of the State of Arizona, to wit; the DEPARTMENT OF TRANSPORTATION (the "DOT") and the ARIZONA BOARD OF REGENTS, acting for and on behalf of ARIZONA STATE UNIVERSITY, (the "University").

I. RECITALS

1. The DOT is empowered by Arizona Revised Statutes Section 28-401 to enter into this agreement and has by resolution, a copy of which is attached hereto and made a part hereof, resolved to enter into this agreement and has delegated to the undersigned the authority to execute this agreement on behalf of the DOT.

2. The University is empowered by Arizona Revised Statutes Section 15-1626 to enter into this agreement and has delegated to the undersigned authority to execute this agreement on behalf of the University.

3. The DOT and the University desire to conduct research and achieve the development and implementation of effective accelerated pavement testing, at an estimated cost of $30,000.00, all at DOT expense, hereinafter referred to as the Project.

THEREFORE, in consideration of the mutual agreements expressed herein, it is agreed as follows:

II. SCOPE OF WORK

1. The DOT will:

a. Appoint a Project coordinator within the DOT's Transportation Technology Group to interface with the University relating to the research and development.

b. Provide the University with information and data as may be reasonably available to assist in the Project research and development.

c. Reimburse the University within forty-five (45) days after receipt and approval of monthly invoices, in a total amount not to exceed $30,000.00.

2. The University will:

a. Appoint a Project coordinator at the University (ASU) to interface with the DOT relating to the research and development.

b. Accomplish the research and development generally in accordance with Exhibit A, which is attached hereto and made a part hereof, including effective countermeasures to reduce accidents in work zones, and a final report documenting the program, data derived, and the final results. Such reports will be in a format compliant with the DOTs "Guidelines for Preparing Research Reports."

c. No more often than monthly, invoice the DOT in the form of Exhibit B attached hereto, supported by narrative reports and an accounting of monthly costs and expenditures on the Project. Upon completion of the Project, provide the DOT with a detailed final report.

III. MISCELLANEOUS PROVISIONS

1. Title to all documents, reports and other deliverables prepared by the University in performance of this agreement shall rest jointly with the DOT and the University.

2. This agreement shall become effective upon signature by the parties hereto, and shall remain in force and effect until completion of said Project and reimbursements; provided, however, that this agreement, may be cancelled at any time prior to the commencement of performance under this agreement, upon thirty (30) days written notice to the other party.

3. The parties agree to comply with all applicable state and federal laws, rules, regulations and executive orders governing equal employment opportunity, immigration, nondiscrimination and affirmative action.

4. This agreement may be cancelled in accordance with Arizona Revised Statutes Section 38-511.

5. The provisions of Arizona Revised Statutes Section 35-214 are applicable to this contract.

6. In the event of any controversy which may arise out of this agreement, the parties hereto agree to abide by required arbitration as is set forth for public works contracts in Arizona Revised Statutes Section 12-1518.

7. All notices or demands upon any party to this agreement relating to the agreement shall be in writing and shall be delivered in person or sent by mail addressed as follows:

Department of Transportation Joint Project Administration 205 S. 17th Avenue - 616E Phoenix, AZ 85007	Arizona State University Research & Creative Act. PO Box 871603 Tempe, AZ 85287-1603

8. The parties recognize that performance by ASU under this Agreement may be dependent upon the appropriation of funds by the State Legislature of Arizona. Should the Legislature at any time fail to appropriate the necessary funds for such performance, the, by written notice to the DOT, ASU may cancel this Agreement.

IN WITNESS WHEREOF, the parties have executed this agreement the day and year first above written.

STATE OF ARIZONA

THE ARIZONA BOARD OF REGENTS acting for and on behalf of ARIZONA STATE UNIVERSITY	**DEPARTMENT OF TRANSPORTATION**
By Janice D. Bennett 4-3-98 JANICE D. BENNETT, Director Office of Research and Creative Activities	By TIM WOLFE Ass't State Engineer

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RESOLUTION

BE IT RESOLVED on this 18th day of March 1998, that I, the undersigned MARY E. PETERS, as Director of the Arizona Department of Transportation, have determined that it is in the best interests of the State of Arizona that the Department of Transportation, acting by and through the Intermodal Transportation Division, to enter into an agreement with ASU for the purpose of defining responsibilities for conducting research for accelerated pavement testing.

Therefore, authorization is hereby granted to draft said agreement which, upon completion, shall be submitted to the Assistant State Engineer for approval and execution.

DAVID ALLOCCO, Manager
Engineering Technical Group
for Mary E. Peters, Director

ACCELERATED PAVEMENT TESTING

Arizona SPR Research Project 468, Phase I

Work Plan Submitted to:
Arizona Department of Transportation
Director's Support Division
Arizona Transportation Research Center

Submitted by:
Arizona State University
Department of Civil and Environmental Engineering
Tempe, Arizona 85287-5306

Principal Investigator:
Emmanuel B. Owusu-Antwi, Ph.D., P.E.

March 11, 1998

Janice D. Bennett
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TABLE OF CONTENTS

ACCELERATED PAVEMENT TESTING

PROPOSAL TITLE SHEET

Proposing Agency:	Arizona Board of Regents acting on behalf of Arizona State University Box 871603 Tempe, Arizona 85287-1603
Person Submitting Proposal:	Janice D. Bennett, Director Office of Research & Creative Activities
Proposal Date:	January 19, 1998
Principal Investigator:	Emmanuel B. Owusu-Antwi, Ph.D., P.E. Assistant Professor, Department of Civil & Environmental Engineering Arizona State University Tempe, AZ 85287-5306 Tel: (602) 965-0199 Fax: (602) 965-0557 E-mail: Emmanuel.OwusuAntwi@asu.edu
Proposal Written by:	Emmanuel B. Owusu-Antwi, Ph.D., P.E.
Administrative Officer:	Lori Gabriel, Sponsored Projects Officer Office of Research and Creative Activities Tel: (602) 727-6527 Fax: (602) 965-0649
Proposed Contract Period:	4 months, excluding 45-day review period (04/01/98 - 07/31/98)
Total Contract Amount:	$29,993

INTRODUCTION

Pavements, like other infrastructure, machinery, and equipment, deteriorate over long periods of time in real life. As a result, testing, evaluation, and validation of new technologies for pavements sometimes require observing their performance over long periods. One key advantage of this approach is the ability to study the interaction between traffic loading, the environment, and aging on pavement performance. Current examples of this approach to pavement testing include the Federal Highway Administration (FHWA) Long Term Pavement Performance (LTPP) study, the mainline portion of the Minnesota Road Research Project (Mn/Road), and the Ohio SHRP Test Pavement.

The disadvantages of in-service pavement studies include the long completion times required before meaningful results can be implemented in the field. Also, while conventional traffic loading on in-service pavements eliminates the cost of special equipment for loading, traffic monitoring to measure the loads applied is often costly and can provide inaccurate data even with the best equipment. In many instances, it is also very difficult to obtain meaningful and concrete results from analysis of the observational data collected from such studies. This is because it is often difficult to obtain data from existing pavements that fit neatly into an experimental design.

An alternative that has become increasingly attractive in the pavement industry is accelerated pavement testing (APT). One approach involves accelerated loading of specially constructed test tracks or loops with vehicles of know loads (Epps et al. 1998). In a second approach, test sections are loaded with fixed mechanical devices that simulate traffic loading (Bonaquist et al. 1998; Roberts et al. 1997; Kadar 1987; Autret 1987). Mobile mechanical loading devices are also available that can be used on test sections or in-service pavements (Harvey et al. 1998, 1996; Hugo et al. 1997, 1996a, 1996b). A variation of the last approach involves the use of a model mechanical loading device in laboratory tests (Van de Van 1997; Nourelhuda and Mamlouk 1997; Van der Merwe 1992). By accelerating the application of loads using any of these methods, data for evaluating the effect of new materials, design features, and construction practices on pavement performance can be acquired in a relatively short time.

With new materials, design features, and construction practices for pavements being offered frequently, accelerated pavement testing is likely to continue to be one of the most utilized pavement testing methods. It is particularly suitable for the development, evaluation, and validation of potentially innovative techniques for improving pavement design and construction. Such innovative techniques, that can significantly increase long-term pavement performance and reduce life-

cycle costs, continue to be critically important in the pavement industry as funds available for improvements continue to diminish. As a result, a number of state highway agencies have either instituted APT programs or are investigating the potential of using the technology to improve their pavement practices.

This study will investigate the usefulness of implementing an APT program in Arizona for pavement research. As a progressive transportation agency, Arizona Department of Transportation (ADOT) is often among the first group of agencies to evaluate and implement new pavement technologies. This includes assessment of new materials, designs, and construction practices. Examples of some of the pavement research issues ADOT is facing include Superpave implementation and verification. Efforts are also underway to develop improved performance-related specifications, improved maintenance strategies, and improved rehabilitation design. These often require the use of innovative methods for developing and evaluating new technologies that have to be implemented within relatively short periods. Implementation of APT technology could offer ADOT a means of evaluating or validating new technologies in a timely manner.

PROBLEM STATEMENT

Current methods for developing and validating technologies for use in the pavement industry typically consist of constructing test sections and evaluating their performance in real time. This approach is sometimes necessary due to the interactions between traffic loading, environmental effects, and the pavement structure itself. Simulating these interactions in the laboratory is often difficult if not impossible. However, constructing test sections has several disadvantages; it is costly and takes ten to fifteen years to properly evaluate. For a state like Arizona, with a small tax base but high growth rate, this makes it very difficult to compare the effectiveness of competitive pavement designs, materials, or construction practices in the short term.

Accelerated pavement testing (APT) may offer a solution to these problems. It consists of applying loads at a more rapid rate, greater than normally encountered on pavements in service. Thus, for example, a twenty-year pavement loading can be applied in as short as one to four months. This allows for immediate feedback on the success of the materials and design strategy. However, it only provides a relative comparison since it cannot properly account for the long-term environmental and aging effects. It also has some other disadvantages.

Present APT applications use either a facility specifically designed for that purpose (off-roadway APT) or an APT device to apply loads to an existing highway (field APT). Field APT requires a lane to be occupied continuously for

one or more months and thus requires full-time lane control. This approach is expensive but allows an assessment of the pavement performance under actual field constructed conditions. Off- roadway APT is also expensive, since a pavement section needs to be constructed exclusively to conduct testing. Furthermore, the purchase and operation of the APT device in either scenario is expensive.

Consequently, although APT has been used for approximately 30 years, it has only gained widespread acceptance in the last 10 years. The FHWA currently operates an accelerated loading facility at its Turner-Fairbank Highway Research Center and has also constructed one in Nevada called WesTrack. The Nevada facility is being used to evaluate Superpave mixes and to assess the effect of selected asphalt concrete mixture properties on pavement performance. The California DOT (Caltrans) has recently purchased two APT devices. Caltrans intends to use their equipment to quickly develop relative pavement performance comparisons. They are currently completing a study relating specific construction variability to predicted pavement performance.

With the APT capability recently developed at WesTrack and Caltrans there is a unique opportunity for ADOT to participate in APT testing through pooled fund efforts. This testing could include, but would not be limited to, the establishment of realistic performance-related pay factors, comparison of Superpave mixes, and the evaluation of innovative construction materials. It may be possible to cost-share the construction of test sections at WesTrack or at the Caltrans APT, arrange for testing of pavement sections within Arizona, develop some accelerated pavement testing capability within Arizona, or combine all of the preceding concepts.

Potentially, there are a number of applications for APT in Arizona that may include the following:

1. Validation of the performance of Superpave and other flexible pavement mix designs used in Arizona, especially those developed and used by local communities. This would allow immediate feedback prior to widespread use.

2. Field evaluation of ADOT's pavement test sections thus allowing more effective decision-making in the short term. This would require bringing an APT device to Arizona, establishing traffic control, and conducting field-testing.

3. Evaluation of the effectiveness of various surface treatment strategies such as will be done in SPR-371–Maintenance Cost Effectiveness Study. This would also allow immediate feedback prior to widespread use.

4. Validation of the in-service pavement performance characteristic of the SHRP GPS and SPS test sections in Arizona. ADOT has invested approximately $5 to $6 million dollars in the construction of over 125 test sections across the state.

In light of these factors, an evaluation of an Arizona APT concept is essential at this time. It would include an evaluation of the reasonableness of using APT techniques as a tool in the pavement evaluation process for Arizona, and if appropriate, the development of a plan to implement an Arizona APT.

OBJECTIVES OF THE PROJECT

The overall goal of this project is to evaluate the reasonableness of using APT technology to conduct pavement research in Arizona. This goal will be accomplished by meeting the following two key objectives.

1. Evaluate the effectiveness of using APT technology for the following in Arizona:

    - Determining the effectiveness of surface treatments.
    - Establishing the relationship between pay factors and pavement performance.
    - Validating the performance of Superpave and other mixes used in Arizona.
    - Accelerating the evaluations of pavement test sections in Arizona.
    - Other pavement research activities of significance in Arizona.

2. Develop a plan, with substantiated estimates, for implementation of an Arizona APT program that outlines the costs, funding scenarios, resource needs, logistics, partnerships, and other pertinent information.

WORK PLAN

Introduction

A work plan has been developed that describes the approach to be followed by the research team. To develop this work plan, a preliminary literature review was

conducted to obtain background information on APT and on applications of the technology for pavement research. Alternative approaches available for conducting the research were considered and evaluated. The work plan presents an approach that will offer the best chance of accomplishing the project's objectives.

Research Team

A team comprised of three individuals has been assembled to conduct the work for this project. Dr. Emmanuel B. Owusu-Antwi will serve as the principal investigator responsible for the day-to-day technical and overall management of the project. He will be responsible for completing all the tasks of the project and for coordination of the research activities with the ADOT project manager, Mr. Frank McCullagh.

Dr. Owusu-Antwi will be assisted by Dr. Mike Mamlouk. Dr. Mamlouk will also provide in-house quality review to ensure that all deliverables and products submitted to ADOT are of the highest quality. Based on the research team's experience on previous projects, such in-house quality reviews have a tremendous influence on the success of projects. A graduate student will be available to assist Dr. Owusu-Antwi as required. Further information on the qualifications of the research team can be found in the section *Staffing Plan*.

Project Management Approach

The work for the project will be conducted in five tasks. There will be a kickoff meeting to review the scope of work and work plan in task 1. This will be followed by an evaluation of the effectiveness of using APT technology for pavement research in Arizona in task 2. Upon completion of task 2 and using the results obtained, a plan for implementing an APT program in Arizona will be developed in task 3. A final report that documents the entire research effort, including conclusions and recommendations, with be prepared in task 4. In task 5, a presentation of the research results and conclusions will be made to the Research Council to conclude the project.

Approach

The APT technologies currently available have been tried and tested by many agencies in the past decade. Their uses have included studies to validate Superpave mixes (Epps et al. 1998; Bonaquist and Mogawer 1997; Van de Ven et al. 1997). Other researchers have used the results from accelerated pavement

testing to evaluate and validate criteria for mechanistic-based analysis and design of pavements (Groenendijk et al. 1997; De Beer 1997; Jordaan 1992). Engineers in France have used the LCPC circular APT facility to among other things evaluate the effectiveness of different maintenance and rehabilitation designs, as well as to determine the critical times for preventive maintenance (Auret et al. 1987; De Boissoudy et al. 1992). Huhtala and Pihlajamaki (1992) used the same LCPC facility for pavement research on load equivalencies, and Bonaquist (1992) used the FHWA Pavement Testing Facility to assess the relative damage potential of wide based single tires. In 1996, the state of Texas completed the 5-year development of the prototype Texas Mobile Load Simulator (TxMLS) (Hugo 1991, 1996a, 1996b). This facility is being used in several research studies as part of the state's overall strategic pavement research program (Pilson et al. 1995; Lee et al. 1997; Hugo et al. 1997). Another state that is heavily involved in APT pavement research is California (Nokes et al. 1997; Harvey et al. 1998).

Clearly, many options are available to ADOT for conducting future pavement research using APT. ADOT has a unique chance to evaluate the effectiveness of different APT technologies for Arizona's specific research needs. With suitable APT technologies identified, one could ostensibly select the best technologies and include them in a comprehensive APT program for Arizona. However, because of cost considerations, it is likely that a final APT program will not necessarily include the best APT technology for every research application. However, an achievable goal is an APT program that allows ADOT to meet Arizona's pavement research needs in a more timely manner and more effectively use the pavement funds available.

With this is mind, the approach selected by the project team to meet the objectives of this project includes the following:

1. A clear identification of the specific pavement evaluating, testing, and research needs of ADOT to which APT concepts can be applied.

2. Identification of the different APT technology options available that match Arizona's research needs.

3. Selection of the elements for an Arizona APT program for conducting research in the state as part of ADOT's strategic pavement research program.

4. Development of an implementation plan for an Arizona APT program.

This section of the proposal includes details of this approach. It provides details of the work to be accomplished in five tasks to meet the project's objectives. Also, it addresses how the technical challenges anticipated will be tackled to ensure that the highest quality products and deliverables are obtained.

Task 1 – Kickoff Meeting

A kickoff meeting between the Project SPR-468 Technical Advisory Committee (TAC) and the principal investigator was held on March 4, 1998. The objective of meeting was to ascertain if the proposal submitted effectively addressed the scope of work, and if not what changes were required to address any deficiencies. The principal investigator provided an overview of the work planned to the TAC and the TAC provided several review comments for improvement of the work plan. These comments have been incorporated into this work plan that describes the final scope of work for this project. It provides specific details of how this project will be accomplished by the project team.

Task 2 – Evaluate Effectiveness of APT

In task 2, the project team will evaluate the effectiveness of APT technology for pavement research in Arizona. This will require accomplishing the following:

1. Identifying specific pavement evaluation, testing, and research needs in Arizona to which APT concepts can be applied.

2. Evaluating the effectiveness of using current APT technology for Arizona's pavement evaluation, testing, and research needs.

Subtask 2.1 – Identify Research Needs for APT Technology Application

The major pavement research areas in Arizona with the potential for application of APT concepts can be grouped into the following categories:

1. Validation of the performance of the Superpave and other mixes developed and used by ADOT and local communities.

2. Evaluation of the effectiveness of various surface treatment strategies such as will be done in SPR-371–Maintenance Cost Effectiveness Study.

3. Evaluating the impact of different materials, design features, and construction practices on establishing a relationship between pay factors and pavement performance.

4. Accelerating the evaluation of in-service pavement test sections in Arizona to allow more effective decision-making in the short term.

5. Other pavement research activities of significance in Arizona, such as validation of the in-service pavement performance characteristic of the 125 SHRP GPS and SPS test sections into which ADOT has invested approximately $5 to $6 million dollars.

These categories are broad but provide a good overview of the potential areas for APT technology application in Arizona. In this subtask, the research team will flesh out in detail the pavement needs of ADOT that can benefit from APT technology application. The project team is aware of some of these needs. Therefore, as a first step a draft technical memorandum that identifies the various issues facing the Department in pavement testing, evaluation, and research will be prepared. The project team will review current ADOT reports and documentation for additional information to include. We will coordinate with the ADOT project manager as well to ensure all the necessary topics are covered.

The project team proposes to circulate the completed draft memorandum through the project manager to the key departments at ADOT to obtain feedback. In addition, the memorandum will be submitted to the TAC for feedback and clarification. Based on the comments received, a final technical memorandum will be prepared that will include details of ADOT's pavement needs to which application of APT concepts will be beneficial. This memorandum will also serve as an outline for an APT-based strategic pavement research program for Arizona that will be developed in task 3.

Subtask 2.2 – Effectiveness of APT Technology for Arizona's Research Needs

In subtask 2.2, the project team will identify specific APT equipment types and facilities that can be used effectively to meet Arizona's research needs. Several researchers, including those from the neighboring WesTrack and Caltrans APT programs, have successfully used APT technology. The objective will be to assess how effectively APT concepts can be used to meet pavement research needs in Arizona, taking into consideration the uniqueness of some of our needs. APT technology can be divided into four categories based on their design and method of load application:

1. Full-scale test tracks loaded with trucks of known load, e.g., WesTrack, Mn/Road LVR, AASHO Road Test.

2. Fixed mechanical loading devices
   - Linear mechanical loading devices, e.g. ALFs
   - Circular mechanical loading devices, e.g., LPCP Nantes.

3. Mobile mechanical loading devices
   - Heavy vehicle simulator (HVS), e.g., South Africa, Caltrans
   - Mobile load simulator (MLS), e.g., TxMLS.

4. Devices for small-scale laboratory tests
   - Model mobile load simulator (MMLS) (e.g., South Africa, Texas, and Arizona)
   - Shear tester.

The project team will investigate the effectiveness of these APT technologies for Arizona's research.

Two approaches will be used to retrieve the information needed for the analysis planned. In the first approach, the research team will conduct a questionnaire survey of current APT technology users to determine their experience with the technology. The questionnaire will address the ADOT's research needs identified in subtask 2.1 and ask for information on the cost, resources, and facilities required for an APT program among other things.

It will request information on all the pavement types that have been evaluated using APT technology and the mix design methods and tests used for the pavements tested. This will include pavements built with Superpave mixes designed using the gyratory compactor, as well as those built with other mixes and materials designed with other equipment. The respondents will be asked to include a list of their project reports on APT; this can be used as one of the measures of success of their programs. The project team will submit a draft of the questionnaire and a list of prospective respondents to the TAC for approval before the questionnaire is distributed. The information obtained will be summarized and tabulated to provide information on the use of APT technology by previous users.

To supplement the information obtained from the questionnaire survey, the research team will concurrently conduct a comprehensive literature search to obtain additional information on APT use for applications similar to those

envisaged in Arizona. The principal investigator has already been in contact with some of the agencies (WesTrack, Caltrans, and FHWA) conducting APT in the nation and obtained assurances of their cooperation. Also, a sizeable number of the material on APT that will be required is already available to the project team from the ASU library system and personal records.

A summary of the results of a preliminary literature search that has been completed are presented in the section *Summary of Literature Search*. A review of the literature shows that there has been fairly rapid development of APT technology in the United States since Fall 1984. Acting on the recommendations of participants of a conference it sponsored in the spring of that year, the FHWA initiated its current accelerated pavement testing program (Bonaquist et al. 1998). Others soon followed and currently there are now at least 10 additional APT programs that are either in operation or are being developed in the United States. Additional information is also available on the APT programs of several foreign nations. These include Australia and France that started their APT programs in 1984. Spain, Britain, the Netherlands, Sweden, and Finland have APT programs also. South Africa has a program that dates back to the 1970s (Rust et al. 1997). Therefore, a wealth of information is available to study the effectiveness of APT for various pavement research needs.

Using the search facilities available through the Arizona State University library system and the ADOT library, the research team will search the following databases for additional pertinent information:

- National Technical Information Services (NTIS)
- Transportation Research Information Service (TRIS)
- Federal Research in Progress
- EI Compendex.

The results expected from task 2 is information on the effective APT options available for the different research needs in Arizona. For example, this will include information on the various APT options that have been effectively used to validate the performance of Superpave and other mixes. Other options may be more effective for evaluating surface treatments. With the information obtained and our knowledge of APT capabilities, the project team will assess the effectiveness of APT for the research needs identified.

Task 3 – Develop Implementation Plan

This task calls for the development of a plan for implementation of an Arizona APT that includes substantiated estimates of the overall resources required. To do this effectively it will be necessary to take into account both the present and future needs of an Arizona APT program. Therefore, an essential undertaking in task 3 will be to develop a strategic pavement research program for an Arizona APT program. This strategic pavement research program will identify the objectives and key milestones of ADOT's future APT pavement research program.

An important consideration will be how an APT research program will be integrated into the Department's overall pavement research program. The technical memorandum developed in subtask 2.1 will be very useful for this purpose. The implementation plan will provide specific details on how an Arizona APT program will benefit ADOT's pavement research objectives identified in the memorandum.

The implementation plan will also identify the various parts or elements of an Arizona APT program, i.e., the equipment and resources. As indicated previously, it may be possible to find that the APT technology best for validating the performance of Superpave and other mixes, may not necessarily be the best for determining the effectiveness of surface treatments, or establishing relationships between pay factors and pavement performance. Therefore, there may be different APT technologies that can be included in an Arizona APT program. For example, it may include a mobile mechanical loading devices (e.g., HVS) for validating Superpave and other mixes in the field, but rely on an ALF for surface treatment evaluations. Because of the information available on the experience of previous users of the technology, we expect to be able to select the best elements for an APT program. Based on an economic analysis comparison of possible options, it should provide the most benefit to Arizona.

Following are examples of the options that will be considered for analyses:

1. Cost-sharing construction of test sections at the WesTrack or Caltrans facilities.

2. Arranging for testing of test tracks or specially constructed pavement sections within Arizona, e.g. with the Caltrans HVS or TxMLS.

3. Developing full-blown APT facilities within Arizona.

4 Some combination of the above (including consideration of the use of laboratory-based devices for small-scale tests).

With this as a starting point, a more comprehensive description of the alternative options will be generated. Issues that will be investigated include the possibility of developing an APT program with participation from the transportation industry, the state universities, and neighboring states. Examples of possible partners include the Arizona Rock Products Association, the Arizona chapter of the Associated General Contractors, Arizona State University, University of Arizona, New Mexico, and other transportation-related entities.

An approach that will be used to compare the alternatives has been used successfully by Rose and Bennett (1994) to evaluate the benefits of the Australian ALF. The range of benefits and costs for each alternative will be established using information obtained from previous users. Some of the factors that will be considered include the following:

- Cost
- Funding scenarios and mechanisms
- Resource needs
- Logistics
- Partnerships
- Resources available from nearby APT programs
- Future applications

Several of these factors are qualitative and it will be difficult to quantify their benefits. However, by developing clear descriptions of the linkages between the outcomes of the choice of APT technology and the resulting reductions in ADOT costs, it will be possible to assign benefits in dollar terms to most of the intangible factors. Once a standard approach is used to estimate the benefits of the different options, regular economic analysis will be adequate for comparing alternatives. After carefully evaluating the alternatives we will determine the best "package" that will provide the most benefit to ADOT.

A comprehensive implementation plan will be developed for the most feasible package selected for Arizona. The implementation plan will describe in detail the final elements of the APT program selected. This will include a description of the various equipment recommended, the costs, the resources required, and funding scenarios, partnering options, and other important considerations for the implementation of an Arizona APT.

Task 4 – Prepare Final Report

A final report will be prepared to document all the research activities, the data collected, analysis methods, results, and recommendations. The report will address the reasonableness of using APT for pavement research in Arizona and include a plan for implementing an Arizona APT program. The final report will be prepared in accordance with ADOT guidelines for ATRC research reports. Also, a research note not exceeding four pages in length and that summarizes the project will be prepared.

Draft copies of the final report and research note will be submitted to ADOT for review in accordance with ADOT's procedures. It is assumed that the project will be on hold during review of the draft final report and research note. The written comments received will be incorporated into the final report and research note submitted at the project's conclusion.

Task 5 – Executive Presentation

The principal investigator will make an executive presentation to the Research Council on the findings of the project at its conclusion. Prior to the presentation, draft copies of the presentation material prepared will be submitted to ADOT for review upon request. Review comments received from ADOT will be incorporated into the final presentation material. Hard copies of the material will be distributed at the presentation.

Benefits

This study will provide important and concrete results on the reasonableness of implementing an APT program in Arizona. It will provide specific information on the effectiveness of using APT technology to address some of the key pavement issues facing ADOT. A key product will be a plan that, if implemented, will allow ADOT to perform pavement research in a more timely manner. This could mean a considerable shortening of the time required to test new materials, design features, and construction practices. This ability to quickly evaluate and validate new technologies for implementation in the field, will lead to a more effective use of ADOT's pavement funds and substantial savings to the Department.

Work Time Schedule

The work time schedule for the project is shown in figure 1. The schedule shows the beginning times for each task as well as the anticipated times of completion. A beginning time of April 1, 1998 and completion time of July 31, 1998 are assumed for the project in this proposal.

Figure 1. Work time schedule

Tasks	Month			
	April	May	June	July
1. Meeting	Completed			
2. Effectiveness of APT				
3. Implementation Plan				
4. Final Report				
5. Presentation				X

Implementation

This study will provide a plan for implementing an Arizona APT program that will improve the timeliness of conducting pavement testing, evaluation, and research in Arizona.

Facilities Available

All the facilities needed for this project are available to the project team at ASU. No special equipment are required for the conduct of this project. The ASU library system is a state-of-the-art system that will provide the resources required for a comprehensive search of libraries around the world for reference material on APT. These materials will satisfy all the anticipated needs of the project.

STAFFING PLAN

The principal investigator, Dr. Emmanuel Owusu-Antwi, will be directly responsible for the technical and overall management of the project. He will be the primary contact for all technical matters. All administrative matters should be

referred to the ASU administrative officer, Ms. Lori Gabriel, Office of Research and Creative Activities at ASU.

Qualifications of Research Team

The ASU team for this project consists of Dr. Emmanuel Owusu-Antwi, Dr. Mike Mamlouk, and a graduate student. This section provides information on the qualifications of the team.

Emmanuel B. Owusu-Antwi, Ph.D., P.E. – Dr. Owusu-Antwi recently joined the ASU faculty as an Assistant Professor in Civil and Environmental Engineering. His areas of interest are pavement materials, pavement analysis and design, pavement evaluation and rehabilitation, and pavement performance and management. He also has extensive experience in the statistical data analysis.

Dr. Owusu-Antwi recently led the effort to develop new mechanistic-based distress prediction models for the National Pavement Cost Allocation Model (NAPCOM) program. NAPCOM is a state-of-the-art computer program for determining pavement deterioration costs nationwide. The models include prediction models for concrete and flexible pavements and have been implemented in NAPCOM by FHWA. Dr. Owusu-Antwi has served as the principal investigator for similar projects to develop improved mechanistic-based models for the FHWA and FAA.

Dr. Owusu-Antwi has experience developing guidance for pavement design and construction. He recently completed an NCHRP project to develop guidelines for unbonded concrete overlay design and construction. As a Co-PI, he was also a key participant of an NCHRP project to develop a national catalog for pavement design. From 1992-1996, Dr. Owusu-Antwi provided technical expertise on materials sampling and testing for the LTPP program. During that period, Dr. Owusu-Antwi also contributed to the development of the NIMS that houses the LTPP data base and conducted the annual quality assurance checks of the data.

Dr. Owusu-Antwi also has considerable experience is technology transfer. Before joining ASU he had just completed the development of materials for the first edition of NHI's training course *Pavement Subsurface Drainage Design*. As Co-PI he was responsible the development of the course *AASHTO Pavement Overlay Design Procedures* and was an instructor for the *AASHTO Design Procedures for New Pavements* and *Pavement Analysis and Design Checks* courses. The AASHTO courses introduce participants to new and overlay pavement design using the traditional AASHTO method and AASHTO's design software, DARWin. The latter course

addresses the use of mechanistic principles for the analysis and design of asphalt and concrete pavements.

Mike Mamlouk, Ph.D., P.E. – Dr. Mamlouk is a Professor of Civil and Environmental Engineering at ASU. He has several years of experience performing pavement research for agencies including ADOT, FHWA, and SHRP. In particular, he is currently the P.I. for a large contract sponsored by FHWA entitled "Pavement Maintenance Effectiveness - Preventive Maintenance Treatments.". Dr. Mamlouk was the P.I. of the SHRP subcontract (Contract P-015, LTPP Laboratory Testing, Western Region, Subcontract from Western Technologies Inc.). The contract included laboratory testing of AC, aggregate and soil.

Dr. Mamlouk was the P.I. of a multi-year research project funded by the Arizona DOT to develop a mechanistic overlay design procedure. He was also the P.I. of a research project to evaluate typical ADOT asphalt concrete using the AAMAS procedure. Dr. Mamlouk was the P.I. of a research project funded by the U.S. Army Corps of Engineers Waterways Experiment Station in the area of dynamic analysis of pavements. He played a major role in introducing the concept of dynamic analysis as a viable method for pavement evaluation.

Dr. Mamlouk was the P.I. of a research project funded by Sahuaro Asphalt and Petroleum Co. to characterize modified asphalt mixtures using indirect tension, resilient modulus and creep testing. He was also the P.I. of a research project funded by the City of Phoenix to evaluate pavement conditions ant to implement the 1986 AASHTO guide in the design manual of the City which resulted in an annual saving of about $1.2 million.

Cooperative Features

None.